



Quantitative bone SPECT/CT for evaluating treatment response in patient with sternoclavicular arthritis

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Abstract

We report here a case of sternoclavicular arthritis due to SAPHO syndrome in a 60-year-old female in which quantitative values determined using bone SPECT/CT were useful to evaluate response. After celecoxib and alendronate sodium hydrate therapy, the chief complaints were well relieved and post-treatment Tc-99m HMDP bone SPECT/CT examination showed decreased uptake. The maximum standardized uptake value (SUV), peak SUV, mean SUV, metabolic bone volume, and total bone uptake of the untreated lesion were 18, 16, 10, 17 mL, and 180, respectively, which were decreased to 8, 7, 5, 15 mL, and 75, respectively, after the treatment. In comparison with pre-treatment situation, those parameters were decreased by –56%, –56%, –50%, –12%, and –58%, respectively, following celecoxib and alendronate sodium hydrate therapy, likely reflecting treatment response. Quantitative bone SPECT/CT may be useful to evaluate joint inflammatory activity and treatment response in a patient with osteoarthritis.

Keywords

sternoclavicular arthritis, synovitis, acne, pustulosis, hyperostosis, and osteitis, bone scintigraphy, quantitative SPECT/CT, standardized uptake value

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Introduction

Synovitis, acne, pustulosis, hyperostosis, and osteitis (SAPHO) syndrome is a constellation of diversified clinical features including chronic inflammatory osteoarticular lesions and dermatological disorders.^{1,2} Different terminologies have been used to describe such association between osteoarticular and dermatological lesions. The high heterogeneity brings challenges to the diagnosis, management, and research of this rare disease. Further characterization and classification of the disease is needed. Osteoarticular disease plays a fundamental role in the pathogenesis of SAPHO syndrome and is mandatory for establishing the diagnosis. All skeletal regions can get involved, showing variable imaging features in different stages of the lesions.

In the affected skeletal sites, patients experience pain, stiffness, soft tissue swelling, or limitation of motion. Severe disability may be caused by rapidly progressing destructive spondylitis or spinal cord injury due to spine

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ankyloses. Functional impairment caused by osteoarticular disease brings a heavy burden to patients' health and quality of life.

Whole-body bone scintigraphy is an effective and first-line approach to systemic evaluation of osteoarticular lesions in SAPHO syndrome.^{2,3} However, abnormal uptake in joint observed with planar bone scintigraphy cannot be easily and reliably quantified, and semiquantitative visual methods are not adequately sensitive to measure the disease activity and actual response, even with images acquired using single photon emission computed tomography (SPECT). On the other hand, recent advances have resulted in integration of computed tomography (CT) for attenuation correction together with a sophisticated reconstruction technique, which has enabled quantitative measurements with SPECT/CT suitable for derivation of the standardized uptake value (SUV).⁴⁻⁶ It is considered that quantitative SPECT/CT may soon have an enormous effect as an imaging biomarker in the field of modern nuclear medicine and for clinical practice. Here, we report a case of sternoclavicular arthritis due to SAPHO syndrome in which quantitative values were determined with bone SPECT/CT measurements and found useful to evaluate treatment response.

Case report

A 60-year-old female who was diagnosed to have palmo-plantar pustulosis 13 years ago came to our hospital complaining of pustule on the palm, anterior chest pain, and low back pain lasting for 1 month. Tc-99m hydroxymethylene diphosphonate (Tc-99m HMDP) bone SPECT/CT revealed focal and intense uptake in the right sternoclavicular joint, reflecting active sternoclavicular arthritis (Figure 1(a) and (b)). The patient was diagnosed with SAPHO syndrome and had begun celecoxib and alendronate sodium hydrate therapy for 18 months. The second bone SPECT/CT revealed decreased uptake in the right sternoclavicular joint, reflecting suppression of osteoarthritis (Figure 1(c) and (d)) along with clinical improvement.

Two SPECT/CT scans using an integrated SPECT/CT system (Discovery NM/CT 670, GE Healthcare) equipped with a low-energy high-resolution collimator were performed at 3 hours after intravenous injection of 555 MBq of Tc-99m HMDP. SPECT/CT data were analyzed using a commercially available software package (GI-BONE, Aze Co., Ltd, Tokyo, Japan), which provides statistics for various SUVs, such as max, peak, and mean SUV, as well as metabolic bone volume (MBV) and total bone uptake (TBU).⁷ SUVmax was defined as the maximum concentration in the target lesion (maximum radioactivity/voxel volume)/(injected radioactivity/body weight). SUVpeak is defined as average activity concentration within a 1 cm³ spherical VOI centered on the "hottest focus" within the tumor. SUVmean was defined as (total

radioactivity/VOI volume)/(injected radioactivity/body weight). MBV (mL) was the calculated volume obtained by the accumulation of radiopharmaceutical by placing the tumor VOI with the margin threshold set at 40% of SUVmax. TBU was then calculated as SUVmean × MBV. The SUVmax, SUVpeak, SUVmean, MBV, and TBU values of the untreated lesion were 18, 16, 11, 17 mL, and 180, respectively, which were decreased to 8, 7, 5, 15 mL, and 75, respectively, following celecoxib and alendronate sodium hydrate therapy (Figure 2). In comparison with pre-treatment situation, those parameters were decreased by -56%, -56%, -50%, -12%, and -58%, respectively.

Discussion

In the past, semiquantitative methods such as relative count ratios based on planar scintigraphy or SPECT have been employed. However, recent reports indicate that these are inferior to three-dimensional quantification based on SPECT/CT.^{8,9} State-of-the-art SPECT/CT produces objective quantitative data. Using results of robust algorithms of CT-based attenuation correction, scatter correction, and resolution recovery, SPECT/CT generates imaging voxels denoted as units of radioactivity per volume (i.e., kBq/ml). This is fundamentally different from traditional nuclear imaging methods, such as planar scintigraphy, SPECT, and nonquantitative SPECT/CT, which use counts per second for their imaging units. With quantitative SPECT/CT, lesion radioactivity can be normalized for injected radioactivity, resulting in quantitative parameter values, such as percent injected dose and SUV.⁴⁻⁶

Several studies have demonstrated clinical applications of quantitative SPECT/CT for osteonecrosis of the jaw.¹⁰⁻¹² Tofuku et al.¹⁰ evaluated quantitative bone SPECT/CT findings in 32 patients with severe sacroiliac joint dysfunction and demonstrated that a higher SUV tended to show greater symptom severity who also required more advanced treatment. Suh et al.¹¹ reported the usefulness of quantitative bone SPECT/CT for the grade of temporomandibular joint disorder and demonstrated that SUVmax gradually increased from normal (2.82 ± 0.73) to mild or moderately abnormal (3.56 ± 0.76 , $p < .05$) and then to severely abnormal (4.86 ± 1.25 , $p < .05$). Kim et al.¹² demonstrated that SUVmax of quantitative bone SPECT/CT was highly correlated with traditional imaging parameters for medial compartment osteoarthritis severity of the knee.

In conclusion, a variety of indexes, including SUVmax, SUVpeak, SUVmean, MBV, and TBU, determined using quantitative bone SPECT/CT findings are useful to evaluate the activity of osteoarthritis such as sternoclavicular arthritis as well as treatment response. The present case illustrates that quantitative bone SPECT/CT is a useful non-invasive

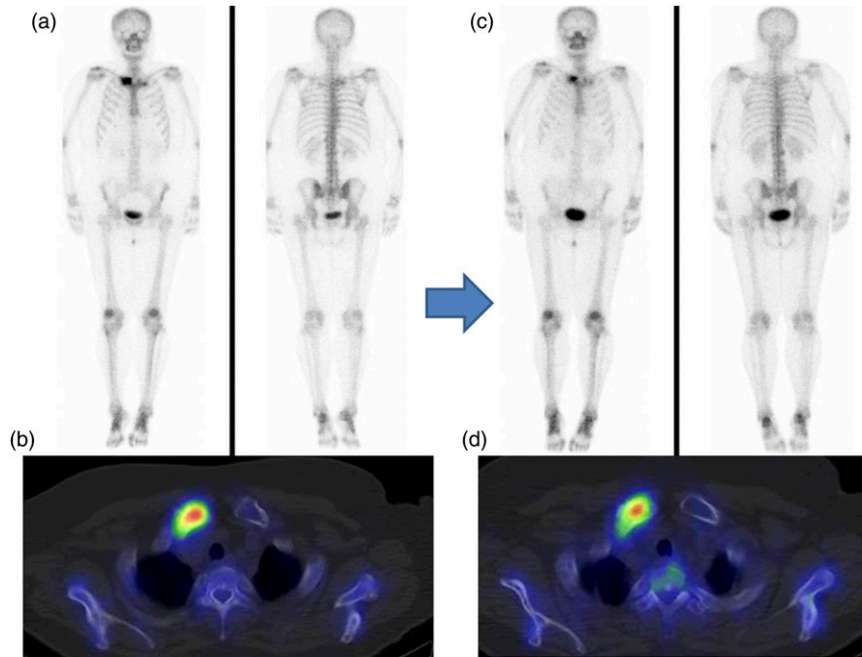


Figure 1. 60-year-old female with sternoclavicular arthritis due to SAPHO syndrome. Pre-treatment (a) whole-body planar bone scintigraphy shows strong accumulation of ^{99m}Tc -hydroxymethylene diphosphonate (^{99m}Tc -HMDP) in the right sternoclavicular joint and (b) bone single photon emission computed tomography/computed tomography (SPECT/CT) image shows strong focal ^{99m}Tc -HMDP uptake in the right sternoclavicular joint. Post-treatment (c) whole-body planar bone scintigraphy shows decrease in focal ^{99m}Tc -HMDP uptake in the right sternoclavicular joint and (d) bone SPECT/CT image shows decrease in focal ^{99m}Tc -HMDP uptake in the right sternoclavicular joint.

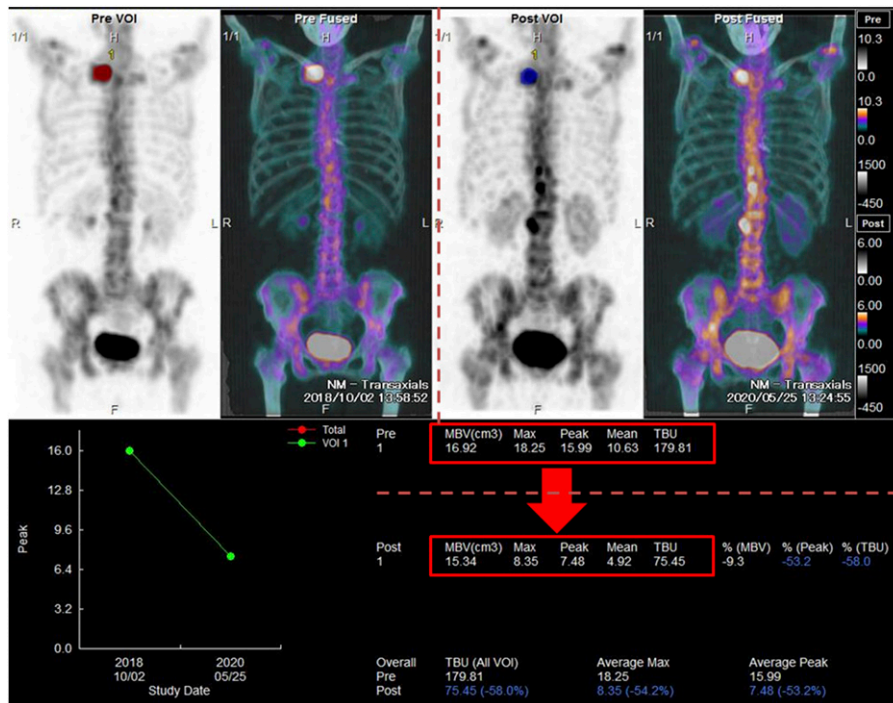


Figure 2. Maximum standardized uptake value (SUV), peak SUV, mean SUV, metabolic bone volume (MBV), and total bone uptake (TBU) of the untreated lesion were 18, 16, 11, 17 mL, and 180, respectively, which were decreased to 8, 7.5, 15 mL, and 75, respectively, following celecoxib and alendronate sodium hydrate therapy.

method for the accurate monitoring of treatment efficacy in osteoarthritis.

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Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Ethical approval

All procedures performed in this study involving human participants were conducted in accordance with the ethical standards of the institutional and national research committees and the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards where appropriate.

Informed consent

This case report has obtained Institutional Review Board approval and the formal informed consent from this patient was waived. We had obtained informed patient consent about all procedures such as bone scintigraphy

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References

1. Nguyen MT, Borchers A, Selmi C, et al. The SAPHO syndrome. *Semin Arthritis Rheum* 2012; 42: 254–265.
2. Schaub S, Sirkis HM, Kay J. Imaging for synovitis, acne, pustulosis, hyperostosis, and osteitis (SAPHO) syndrome. *Rheum Dis Clin North Am* 2016; 42: 695–710.
3. Cao Y, Li C, Yang Q, et al. Three patterns of osteoarticular involvement in SAPHO syndrome: a cluster analysis based on whole body bone scintigraphy of 157 patients. *Rheumatology* 2019; 58: 1047–1055.
4. Zeintl J, Vija AH, Yahil A, et al. Quantitative accuracy of clinical ^{99m}Tc SPECT/CT using ordered-subset expectation maximization with 3-dimensional resolution recovery, attenuation, and scatter correction. *J Nucl Med* 2010; 51: 921–928.
5. Bailey DL, Willowson KP. An evidence-based review of quantitative SPECT imaging and potential clinical applications. *J Nucl Med* 2013; 54: 83–89.
6. Gnesin S, Leite Ferreira P, Malterre J, et al. Phantom validation of Tc-99m absolute quantification in a SPECT/CT commercial device. *Comput Math Methodsmed* 2016; 2016: 4360371–4360376.
7. Kitajima K, Futani H, Tsuchitani T, et al. Quantitative bone single photon emission computed tomography/computed tomography for evaluating response to bisphosphonate treatment in patients with paget's disease of bone. *Case Rep Oncol* 2020; 13: 829–834.
8. Ahn BC, Kim HJ, Lee SW, et al. New quantitative method for bone tracer uptake of temporomandibular joint using Tc-99m MDP skull SPECT. *Ann Nucl Med* 2009; 23: 651–656.
9. Hirschmann MT, Wagner CR, Rasch H, et al. Standardized volumetric 3D-analysis of SPECT/CT imaging in orthopaedics: overcoming the limitations of qualitative 2D analysis. *BMC Med Imaging* 2012; 12: 5.
10. Tofuku K, Koga H, Komiya S. The diagnostic value of single-photon emission computed tomography/computed tomography for severe sacroiliac joint dysfunction. *Eur Spine J* 2015; 24: 859–863.
11. Suh MS, Lee WW, Kim YK, et al. Maximum standardized uptake value of ^{99m}Tc hydroxymethylene diphosphonate SPECT/CT for the evaluation of temporomandibular joint disorder. *Radiology* 2016; 280: 890–896.
12. Kim J, Lee HH, Kang Y, et al. Maximum standardised uptake value of quantitative bone SPECT/CT in patients with medial compartment osteoarthritis of the knee. *Clin Radiol* 2017; 72: 580–589.